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and Maintenance of Way

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THE washing of gravel for ballast as described elsewhere in this issue is comparatively a new process. The washed gravel, it will be noted, is used only as a "covering" and not in the customary tie supporting sense. By this scheme, as found in actual hard service, there is an entire freedom from dust, no matter what the speed of the train may be. For any road having considerable summer travel this is an item not to be neglected. It is not only a great comfort to passengers to be rid of the dust, but it saves untold wear on journals and bearings. Let us hope that some of our good but "dusty" roads will have caught onto this idea and will be prepared for similar work next summer.

THE Detroit River tunnel, which is now being built by the Michigan Central R. R., is another one of the striking examples of large railway expenditures to save time for their passenger and freight service. In getting from the Michigan side to the Canadian and vice versa, generally results in from one-half to three-quarters of an hour's time loss by ferrying. With the tunnel in the proposition is only one of a few minutes' time. This is not as large, of course, as the Pennsylvania R. R. Tunnel under the Hudson, but it has the same idea in mind. E. H. Harriman's "Lucin Cut-off" for the Southern Pacific R. R. across the Salt Lake is another.

In a sense these undertakings are merely selfish on the part of the railroads, we say that they are done to reduce operating expenses which will, of course in time increase the net earnings. There is, however, a much broader view of the situation. It cannot be denied that the railway companies are taking large risks. Railways are, after all, public servants and if they can materially reduce the running time between certain points the general traveling public is certainly largely benefited.

AN INTERESTING paper on the subject of passenger transportation by a subway system, was read by Mr. Arthur S. Robinson, chief engineer of the Metropolitan Elevated Railway, before the Western Society of Engineers, September 19. The main suggestion that he brought forward for the installing of such a system in Chicago was, that there should be a number of loops, each touching a large inner loop. This inner loop was to have a separate system of cars on an inside track separated from the others by a continuous platform.

Mr. Robinson's suggestion of a loop system was productive of much criticism. To get at the proposition a little closer, he had followed the suggestions outlined by Traction Expert B. J. Arnold in his report of several years ago. It was to use three tunnels already the property of the city and extend these underground to the downtown district and to other portions of the city as soon as necessary.

A State street or Wabash Avenue line was also included. The large inner loop was to be under Jackson, Madison, Wabash, and Clark. This would form the terminal loop and passengers desiring to go farther would transfer at the proper place on this loop to their particular line.

Mr. C. V. Weston, chief engineer declared that the capacity of the inner loop would not exceed 60,000 persons in an hour. Mr. M. B. Starring, vice pres. and gen'l mgr. of the Chicago City railway company approved the new freight subway system but further stated that "Mr. Robinson's paper was in keeping with the desires of Chicago people, who all want to leave or arrive at Madison and State streets at the same time and on the same car."

The loop system idea seems to be rapidly declining as the favorite method of rapid handling of passengers. New York has had the same sort of congestion around the Brooklyn bridge terminals that is being felt in Chicago. One of the propositions that seems feasible is the "moving platform" idea, so arranged as to give a continuous train. The ends are planned to be fitted out with a series of platforms with graduated speeds. The well-known successes of this type at the World's Fair in 1893 and the Paris Exposition have also demonstrated the great safety at the minimum loss of time.

AND now we hear that the Long Island Railroad has gone to farming. However, it has been done in such a scientific manner and with such good results that we might possibly classify it as railway engineering. In soil near the Wading river that was said to be "sour," "remarkably late," and entirely lacking in humus, the

company has raised a good crop of rye, together with 39 different vegetables since the 14th of April. A dynamiter and his assistant, followed by a gang of Italians, blew and burnt per day an average of 110 tree stumps running from eighteen inches in diameter to six and one-half feet. In 35 working days, rye was drilled in after soil had been plowed and mellowed by disc and tooth harrow. Within 64 working days the ten acres upon which crops were to be grown had been thoroughly cleared, plowed, harrowed and seeded to rye, a fence put up and because time did not permit of building a portable house, two "condemned" freight cars were pressed into service as living quarters. The freight cars were raised on old ties, and placed into service later as chicken house and hay loft, respectively. When plowing was started, the minute the ground could be worked, the rye was 15 inches high and growing strongly. When the last acre was plowed under, it had grown to the height of 39 inches. The first planting of vegetables was made on April 14th and since then, as stated before, thirty-nine different varieties have been raised and shipped to the market. The greatest amount of manure used on any acre was ten tons. This with wood ashes, the greater part of which was obtained by burning of underbrush, stumps and dead trees, was the only fertilizer used.

The labor has been three men, with the exception of one month, when an absolutely "green" hand was utilized for cultivation. An irrigation plant contributed largely to the success of the crop. We see danger in this proposition if western roads take up the proposition too strongly, for with the help that they have to contend with as a rule for track work, it would mean trouble. There would be no doubt as to the successful raising of crops, but where would the track go to under such conditions?

Surveying for the Simplon Tunnel

NO greater engineering problem than the successful building of the Simplon tunnel has yet presented itself for solution, not only in the execution thereof, but in the preliminary work of establishing lines on which to produce the immense bore. While the work on the tunnel called into play the highest talent of the engineer to overcome almost insurmountable difficulties due to physical causes, the work of the surveyor involved a high order of technical knowledge and skill to obtain accuracy in the direction of the tunnel's axis at the junction of the bores under the center of the mountain. Some interesting figures concerning this great work appeared in Engineering of London, as follows:

Three factors had to be rigorously determined: The difference of level or the gradient between the two ends; the total length of the tunnel, and the azimuth or angle between the axis of the tunnel and a known direction. Of these three factors, the leveling presents the least difficulty, since the results depend upon direct measurement. When the junction was effected under the summit, actual measurement proved that the difference in level between the two partial tunnels was only 0.1 meter, or less than four inches. The length of the road which the borings follow under the mountain need not be determined with the same accuracy as the difference of level or the direction of the tunnel axis. As a matter of fact, the derived values of the length of the tunnel differed by as much as 0.8 meter, that is to say, the probable error of the length based upon the different computations, amounted to nearly thirty-two inches. The most probable length of the tunnel was found to be 19,228.71 meters (11.94 miles), and the actual length measured after completion differed from this quantity by two meters (6.56 feet), or one part in ten thousand.

The most troublesome factor is undoubtedly the direction to be given to the tunnel axis, and here the greatest success was scored. It was found, when the opposite parties met in the center of the boring, that the opposing walls were in perfect alignment. No deviation from true continuity could be detected in one of the walls, while critical examination of the opposite wall could not be made, owing to the projecting rockwork interrupting the view along the advancing gallery.

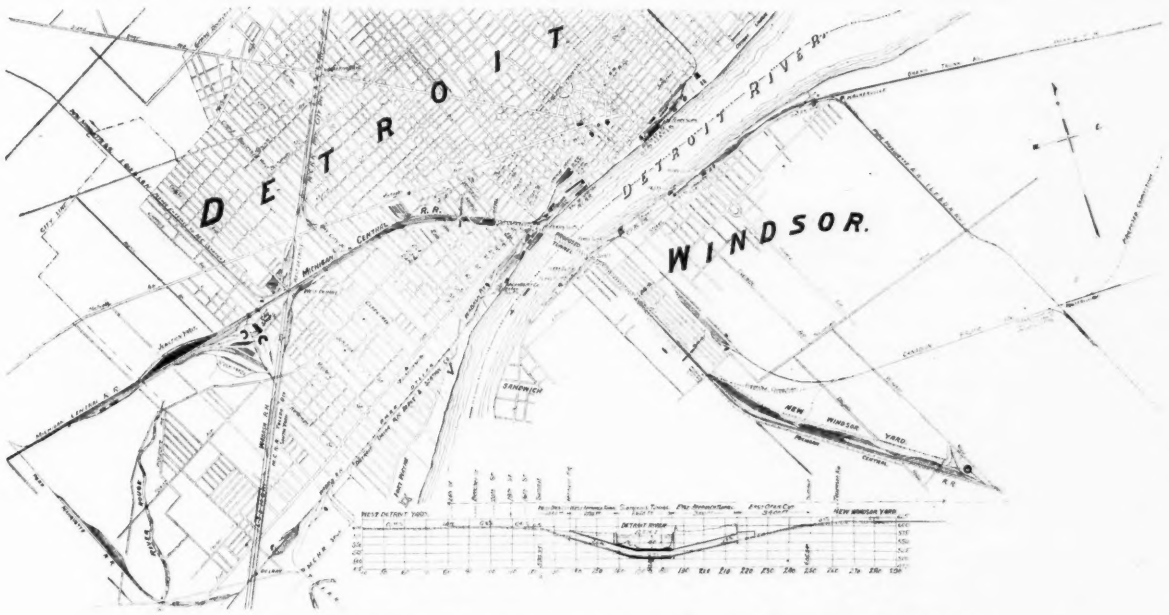
The ventilation of the tunnel was very good, owing to the construction of the parallel tunnel. When it is said that on one occasion a lamp in the tunnel at a distance of 5,600 meters (about three and one-half miles) from the observer was clearly seen with the naked eye, it is sufficient proof of the freedom of the tunnel from dust and smoke. But this effective ventilation was attended by two drawbacks which interfered with the accuracy of observation. The temperature of the fresh air entering through the subsidiary tunnel was gradually increased as it advanced, and the air was therefore capable of holding in suspension more and more moisture. So long as the air retained its warmth, it maintained its transparency, but on its return through the main tunnel it was brought into contact with the cold stone walls, which were of a lower temperature; therefore the air growing colder, deposited its moisture in the form of a cloud, which hung over the entrance and cooler parts of the tunnel, effectually obscuring the lamps and signals.

A source of even greater annoyance and uncertainty was a kind of mirage which displaced or distorted the sources of illumination. It seems to have been not uncommon for a lamp to give rise to, not one image, but two, in the field of the observing telescope. Not only did the observer not know which of the two images to observe, but the true position of the lamp probably corresponded with neither. These two images would be nearly vertical over each other, but the lower one might be displaced nearly forty-five seconds, an angle which would imply an error of an altogether inadmissible quantity. The explanation of the phenomena of double lamp-images, or of the curving of straight lines of light and similar vagaries, is probably the same as that offered in the case of the mirage of the desert. When the heated air near the ground becomes of less density than that immediately above it, an inversion of the ordinary conditions of refraction occurs. The recognition of this disturbing effect is important in all surveying and verification work where atmospheres of different temperatures and densities have to be encountered.

The Michigan Central Tunnel at Detroit

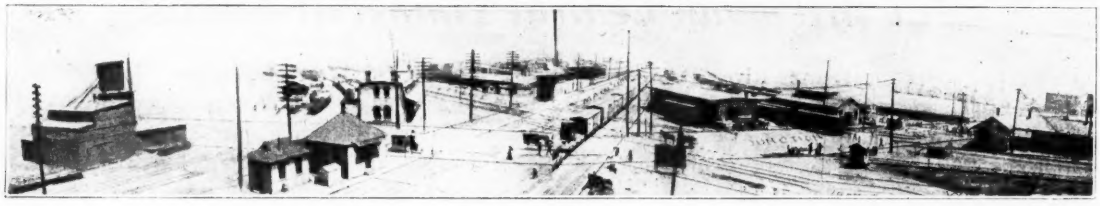
A TUNNEL under the Detroit River, between Detroit, Michigan and Windsor, Canada has been a dream of the Michigan Central for years, and is now about to come to fruition in a construction that will meet the requirements of traffic for that road and its connecting lines at Detroit. To this end an advisory engineering board was appointed in 1905 to formulate and present plans for twin tunnels in which train were to be operated by electricity. This board embraces the well known names of W. J. Wilgus, vice-president of the New York Central; H. A. Carson, chief engineer of the Boston Rapid Transit Subway, who has recently completed the tunnel under Boston Harbor, and W. S. Kinnear, assistant general manager of the Michigan Central, who was formerly chief engineer of that road, and who is to act as chief engineer of the Tunnel Company after the contract is awarded. Since writing the above matters have developed considerably with the contract for the tunnel. The latest news is that work is to be taken up the 1st of October. The Butler Bros.-Hoff Co. of New York have secured the contract for the work at approximately $10,000,000. This does not include the electrification of the tunnel which will come under a special contract. The design of the tunnel to be followed out is the open trench style or which will be found classified as Design A. Steel cylinder forms will be put together in sections sunk to the trench, the sections drawn together and covered with cement through pipes extending from the barges to the tunnel top.

The approaches to the tunnel are also causing considerable trouble. At West Detroit the "Grade Separation" work as it is called is made very difficult from the large amount of traffic and the intersection of the Michigan Central main line with the Toledo Branch, the Lake Shore, Wabash and Grand Trunk railways. By glancing at the accompanying views, the one taken in May (the M. C. main line being in the center of both views) shows the situation very clearly. The next shows the temporary piling to elevate over the tracks of the foreign roads. The larger view shows the main line trestling the second from that in the far background. A photograph taken of the work done in sinking the Detroit shaft is also shown. The Windsor and Detroit shafts have both been completed to date. Owing to the existing natural conditions of the land around the Detroit and Canadian sides the ordinary form of tunneling had to be revised.

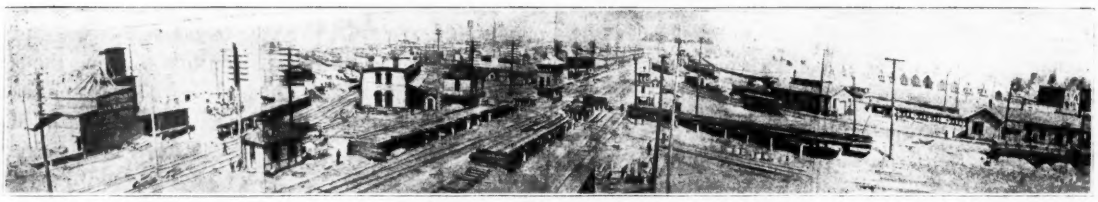


MICHIGAN CENTRAL R. R. DETROIT RIVER TUNNEL-MAP SHOWING TUNNEL APPROACHES AND PROFILE.

To overcome the conditions necessary to hold the gradients at a minimum, that is, to bore as close to the river bed as possible, Mr. Wilgus presented the plan indicated as Design A, which is a trench method, and is said to have the following advantages over the usual shield type, namely: Reduction of lift of traffic; saving in time of construction; minimizing of risks and large saving in first cost. A method indicated as Design B, is the suggestion of Mr. Carson. A plan known as Design C, is a modification of Design A, and Design D, is the usual method such as was used in the Sarnia tunnel of the Grand Trunk, and is now being used in the construction of the tunnels under the North and East Rivers, New York.



MICHIGAN CENTRAL R. R. "GRADE SEPARATION"—WEST DETROIT MAY 1906

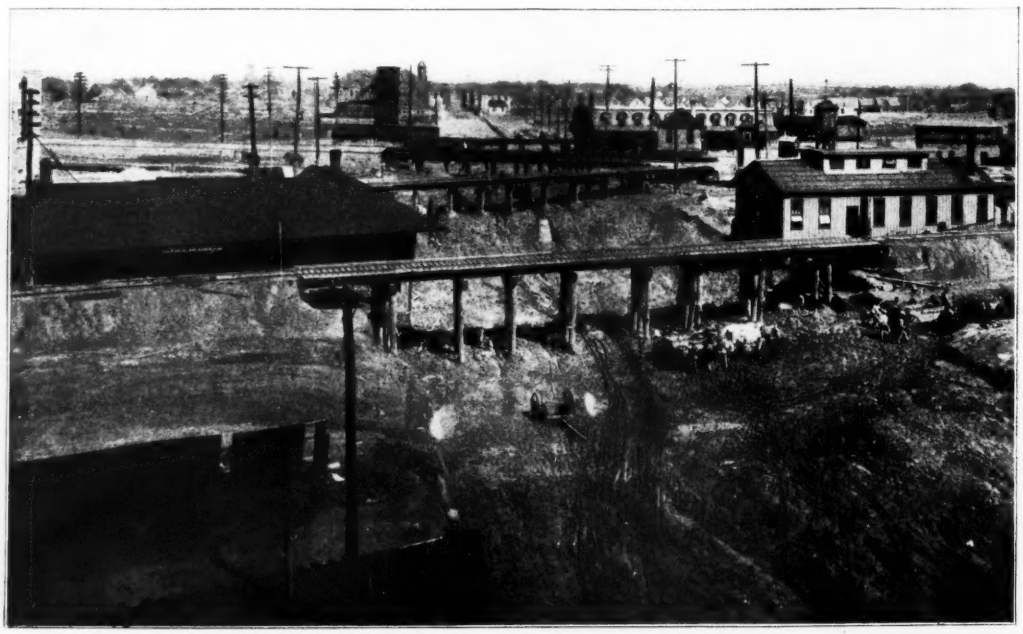


MICHIGAN CENTRAL R. R. "GRADE SEPARATION"—WEST DETROIT JUNE 1906

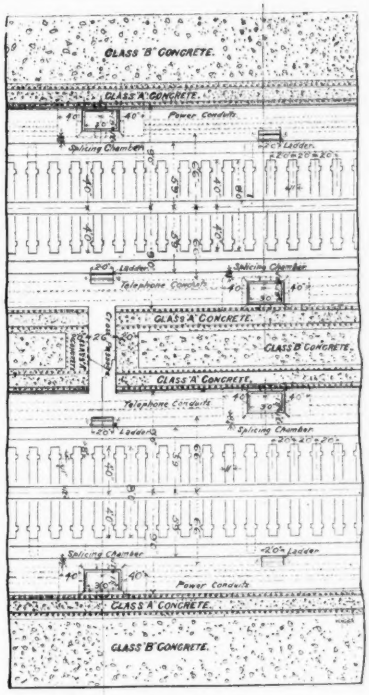
The Design A, or trench method, has the merit of originality, and has been carefully worked out to produce results desired. It is briefly, a method by which the previous material underlying the river is replaced by an imperfectly water-tight material of concrete placed under water, through which, without the use of shields, the inner tubes or tunnel proper may be constructed so as to secure watertightness, continuity of strength and good workmanship, with an absence of high air pressures. This method also dispenses with the use of cofferdams.

The progressive stages of this design are: Dredging of a trench of the approximate dimensions shown on the plans. While certain slopes are assumed as proper for the purpose, flatter slopes may be required, or temporary sheet piling for the retention of slopes within the approximate cross-section. In the bottom of the trench formed, there will be "two-men" stone deposited to a depth of 18 inches, the purpose of which is to form a blanket or barrier between the underlying clay and sand and the superimposed concrete, the latter being floated to place and deposited progressively as the dredging permits, the concrete being applied to the Tremie, bucket, or other process to a depth of approximately two feet.

Forms of timber or steel will be constructed on shore, and coupled together in convenient lengths of from 50 to 500 feet, and will be floated into position and sunk on saddles which are placed on the bed of concrete to receive them. Piling may be driven after the trench is excavated, and cut off to a proper height to receive the saddles, and dispense with the use of blocking and



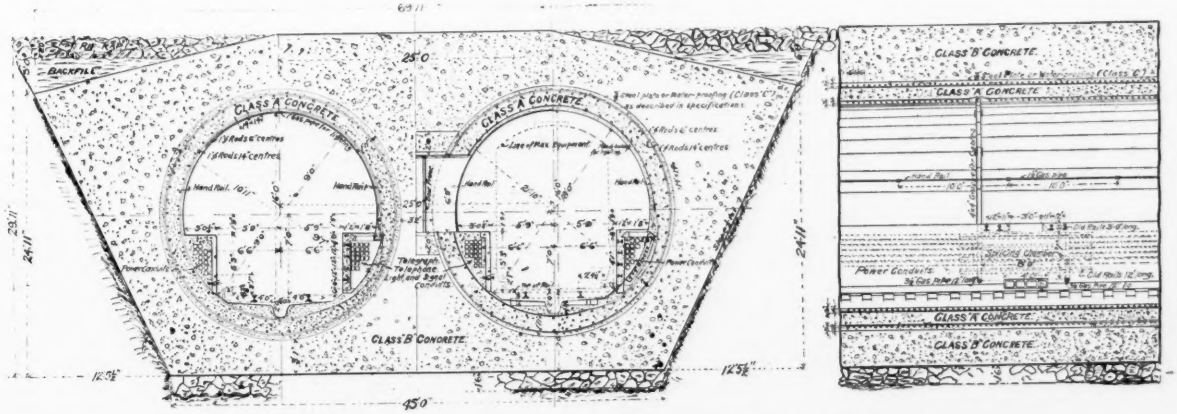
MICHIGAN CENTRAL R. R. "GRADE SEPARATION" WEST DETROIT



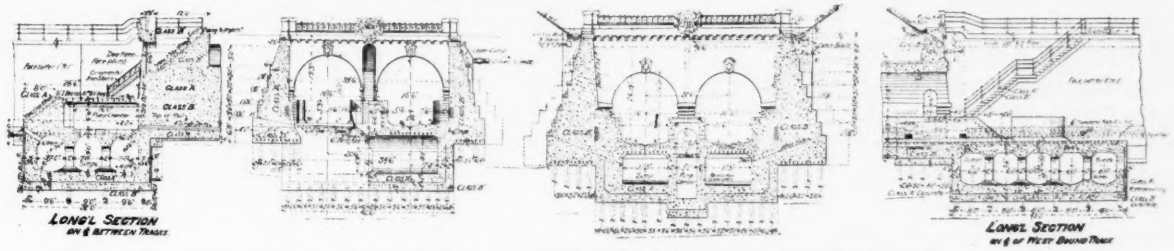
MICHIGAN CENTRAL R. R. DETROI RIVER TUNNEL PLAN OF DOUBLE TUNNEL TUBES

wedging, if so desired. Concrete will be placed under, around, between, and on top of the forms so as to entirely encase them. After a proper time to allow the concrete to set, if leakage is found to be excessive, air of a sufficient pressure may be used to overcome the hydrostatic pressure and enable the waterproofing to be perfected and the inner tube to be finished. Should rolled steel be adopted for the forms, they will be constructed with watertight joints so as to act as waterproofing to prevent the percolation of water against the inner tube. If wooden forms are used, waterproofing will be placed on the outside of the forms before they are sunk into position, so that when the forms are removed the waterproofing will remain in place. This method requires the use of air pressure to prevent hydrostatic pressure from distorting the waterproofing. After each section has been made watertight, the concrete inner tubes are to be reinforced with metal, consisting of ⅜-inch plates placed circumferentially, inside of which are one-inch rods placed at 6-inch centers, and inside of these are also one-inch rods running longitudinally spaced 14 inches center. The same rods are also placed at the inner side of the bore.

In design B the inner tubes are built on floats on land, floated into position and sunk on their foundations. The dredging of the trench, the depositing of the stone, the bed of concrete and the placing of the saddles are substantially the same as Design A. Design C is also practically the same as Design A, with the exception of the details which prescribe a certain style of steel and arrangement of reinforcing. In all cases the dredged material shall be reserved to back fill on the top of the finished structure. Each design has provision for drainage at the bottom of the tube by means of a trench 15 inches deep and 24 inches wide between the rails, having communication with the sump near the center of the subaqueous part of the tube. It should be mentioned that the several methods of prosecuting the work, furnishes contractors an opportunity of making tenders on any one of the designs, or of submitting alternative plans of their own.



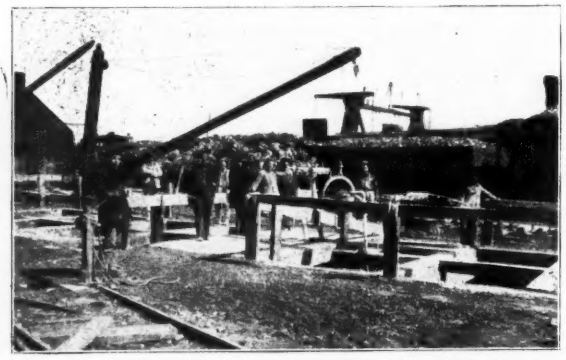
MICHIGAN CENTRAL R. R. DETROIT RIVER TUNNEL—SECTION SHOWING CONCRETE PROTECTION WORK



MICHIGAN CENTRAL R. R. DETROIT RIVER TUNNEL LONGITUDINAL & TRANSVERSE SECTIONS

The total length of the tunnel from open to open is 12,800 feet, and from portal to portal 7,860 feet, while the subaqueous portion is 2,625 feet long. The latter part of the work is wholly tangential, joining the line at each shore with a two-degree curve. The maximum grade on the Detroit side is 2 per cent and that on the Windsor side 1.5 per cent, with a level of about 900 feet at the lowest point of the tunnel. In the preliminary work the borings showed the river bottom to be a conglomerate of hard clay, gravel and sand which with the minimum current of eight-tenths miles per hour at the bottom, furnishes ideal conditions for the trench method of construction, there being no rock nearer than 20 feet from the bottom line of the tunnel; the engineers are therefore not to be hampered by serious physical conditions, and are enabled to proceed with confidence with either of the propositions presented.

Concrete will characterize the construction of the portals, which are designed to be shorn of the usual plain features of such structures. There will be an ornamental stairway at each portal from the street level to the bench level in the tunnel. By the terms of the specifications, the concrete used in the work is designated by letters as follows: Class A, consists of one part of Portland cement, two parts of loose sand, and four parts of No. 2 broken stone or gravel. This mixture is used in the tube construction. Class B, consists of one part of Portland cement, three parts of loose sand, and six parts of No. 1 broken stone or gravel, except when deposited under water when No. 2 broken stone is to be used. This mixture is to be used to surround the tubes and the walls of the portals. Notwithstanding the magnitude of this work it is desired to have the subaqueous part of the work fully in shape inside of one year from the time of beginning operations.



MICHIGAN CENTRAL R. R. TUNNEL—SHOWING SURFACE ARRANGEMENT OF THE DETROIT SHAFT

A New Ship Canal Between the Great Lakes

A ship canal across the narrow peninsula dividing lakes Superior and Michigan has been proposed for some time, and has now taken form in a bill before congress, authorizing Thomas Dolan, Jr., and others to construct such a canal via Whitefish river, Mud lake and AuTrain river with authority to construct and maintain all necessary harbors, locks, dams, tunnels, dykes and piers, without expense to the United States. The proposed waterway, which would leave Lake Superior at a point about 30 miles east of Marquette and enter Lake Michigan above Escanaba would be about 40 miles long and would cost, according to the estimate, $40,000,000. Its benefits would be a saving of something over 300 miles compared with the present route by the Sault Canal and Mackinac. Whether this saving in distance would warrant the great cost indicated is the practical question for investors in the proposed securities to decide for themselves. From an engineering standpoint the project is doubtless possible, as it follows natural waterways most of the distance, although at the dividing summit a cut to a depth of some 220 feet through solid rock, it is believed, would be necessary.

Holding Power of Railroad Spikes

The Forest Service has completed a series of tests to determine the holding power of different forms of railroad spikes. The tests were made on ordinary commercial ties of loblolly pine, oak, chestnut, and other woods. The spikes used were of four kinds: common driven spikes, a driven spike which has about the same form as the common spike with a lengthwise channel on the side away from the rail; screw spikes of the American type; and screw spikes similar to those in use on European railroads and differing from the American spike mainly in the manner of finishing the thread under the head.

The common and the channeled spikes were driven into the ties in the usual manner to a depth of five inches. A hole of the same diameter as the spike at the base of the thread way bored for the screw spikes, which were then screwed down to the same depth as the driven spikes. The ties were then placed in the testing machine and the force required to pull each spike was recorded.

The average force required to pull common spikes varies from 7,000 pounds in white oak, to 3,600 pounds in loblolly pine, and 3,000 pounds in chestnut. The holding power of the channeled spike is somewhat greater. For example, about 11 per cent more force, or 4,000 pounds, is required to pull it from the loblolly pine tie. The two forms of screw spike have about the same holding power, ranging from 13,000 pounds in white oak to 9,400 pounds in chestnut and 7,700 pounds in loblolly pine.

There is a marked difference between the behavior of driven and screwed spikes in knots and in clear wood. Knots are brittle and lack elasticity, so driven spikes do not hold as well in them as in clear wood. In the case of common spikes in loblolly pine the decrease of holding power in knots is as great as 25 per cent. On the other hand, screw spikes tend to pull out the whole knot which they penetrate. This increases the resistance so much that in loblolly pine the increase of holding power of screw spikes in knots is about 35 per cent over that for clear wood.

The Pleasant Lake Gravel-Washing Plant of the L. S. & M. S. Ry.

THE Gravel Washing plant of the Lake Shore at Pleasant Lake, Ind., has been in working order since the first day of June and so far is doing valuable work. Along this road the gravel obtainable has a large amount of sand and naturally forms a rather dusty ballast for the fast trains in the Lake Shore service.

Some 200 acres of land were purchased close to Pleasant Lake, Ind., on the Ft. Wayne branch and work begun early in the spring. For the land, plant, and yard tracks about $90,000.00 was appropriated by the company. With the exception of the contract made for the stripping of the gravel pit, the work has been carried on entirely by the railway company.

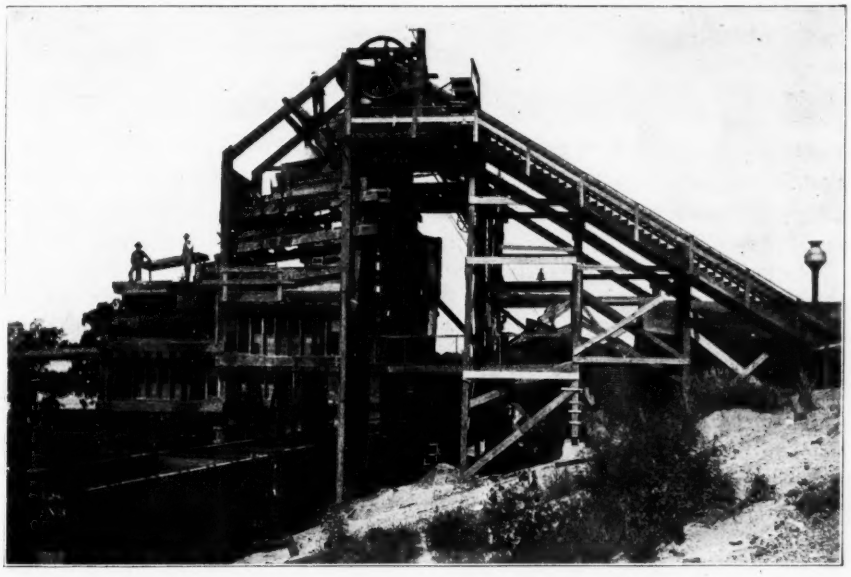
As to the plant itself, the machinery is of the latest type, a 200 H. P. engine supplying the power for the pumps, crusher, and conveyors.

A steam shovel is used for loading raw material, loading about 120 cars per day. The cars are Rodgers hopper bottom convertible type and hold from 30 to 40 yards of gravel according to the way in which they are loaded. Two switch engines are used for handling the loads and empties from the pit to the unloading hoppers, and two below for handling the washed sand and gravel.

By reference to Fig. 1, a car will be noticed standing directly over the unloading hopper. This hopper is a double one and handles two cars at a time. From this hopper the gravel is carried up by means of a continuous steel belt which is shown in Fig. 2. At the top of the plant the belt discharges its load on the top washing table where water is pumped onto the dry gravel, washing gravel through a series of screens, the largest being a 2″ grating at an angle of 45 degrees, so that stones in the gravel which will not pass through it are deflected to the side. Here the large stones are dropped into a crusher and after being crushed are carried again to top. The crusher reduces the stones to about a 1″ diameter. Under this larger grating are screens made of special wire mesh varying in size from ¾″ to ⅛″ opening.

L. S. & M. S. GRAVEL-WASHING PLANT—FIG. 1.

Naturally the material passing through this last opening is nothing more than a coarse sand mixed with the water. This sand and water being carried on by the force of the water itself. The water and sand are checked at the point shown in Fig. 2, where two men are noticed standing at the left of the illustration. Here the sand and water go in a large settling box where sand settles and water flows off over a 16-ft. weir, at end and side. The sand as it settles is discharged into a hopper and thence into cars. The washed gravel, as all of the material is called which will not pass through the finest sieve or screen is dropped directly into a hopper and thence into the cars waiting to receive it. The cars for the washed gravel will be noted as lined up in position in Fig. 2.

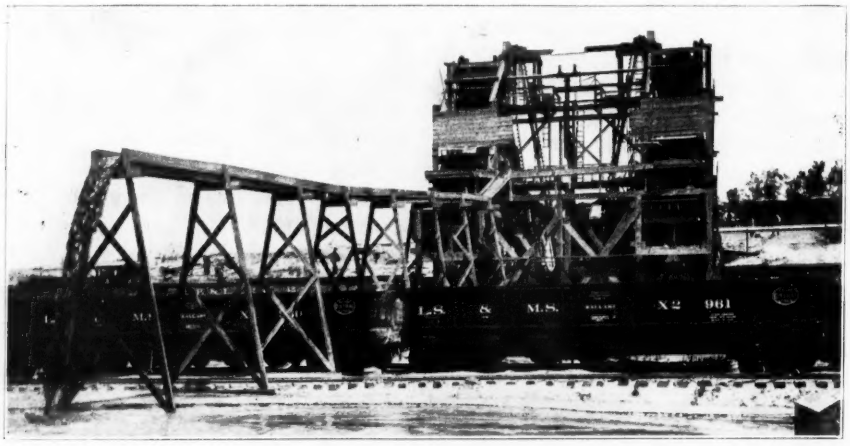


L. S & M. S. GRAVEL-WASHING PLANT—FIG. 2.

The pump is a 10" Worthington Centrifugal. The suction line to the lake is 16", and discharge 10". At the top a man is stationed at the valves which are operated at this point. He is called a "lookout", as in addition to handling the water valves it is his duty to note any trouble in the operation of the plant below him. A vigilant man is used in this position, as he has to note trouble at all points. The system of a continuously arranged plant is admirable. Like anything else, however, it has its defects and any delay or trouble with machinery in the first part of the operation throws the balance out of usefulness.

Cars for sand have to be calked with marsh hay as the wet sand would otherwise soon leak out through the cracks.

One hundred to 120 cars of sand and washed gravel are loaded in a day, the cars of sand being somewhat in excess over the gravel. Fig. 3 shows the long trough that carries off the water after the sand has been caught in sand settlers. The plant is a double one, as will be seen in this illustration, and has a capacity equal to the largest size steam shovel.



L. S. & M. S. GRAVEL-WASHING PLANT—FIG. 3.

On the track previously noted as running over the unloading hopper, a "tip up" track has been constructed. By this the service of a switch engine is dispensed with at times. Cars are pinched off the tracks over the hopper after being unloaded and then drop of their own weight down a grade and up the "tip up" track as far as their momentum will carry them. A switch is located at the foot of this track and the cars are turned onto another track after they start on their downward return.

To carry on this plant four switch engines are in constant use, so that with the engines that carry loads and empties to and from the places that are being ballasted on the main line, the place presents a very busy scene.

A force of 30 men is used to keep up the yards which have a capacity of 150 cars besides the working tracks. For the plant itself there is a washer foreman, a stationary engineer, a valve or "lookout" man, two men for the sand settlers, a blacksmith, carpenter, helpers, etc.

The washed gravel is being used this year for only a very light lift after the old gravel is entirely dug out to the bottom of the ties, in order to do away with dust over as much ground as possible. Next year this territory will be given another and more substantial lift. In service the washed gravel presents a very clean and neat appearance and is free from the dust that is too often present with gravel ballast.

Pennsylvania's Tunnels meet Under Hudson River

After two years and a half of continuous work the eastbound and westbound shields in one of the 23-foot twin tubes, which the Pennsylvania Railroad has been driving under the Hudson river to connect New York and New Jersey, met on Sept. 12. Now men may walk through dry-shod from one State to the other. The second tube, a few feet to the south, is expected to join about October 7th. The meeting of the shields marks the beginning of the completion of one of the most astonishing engineering feats on record. It means the realization of the long-time dream of the Pennsylvania Railroad—to land its passengers in the heart of Manhattan Island. Probably no feat of railway strategy in the history of the United States has attracted more attention throughout the world than this one. Its completion will mark a triumph over difficulties of tremendous magnitude, as this will be the longest tunnel ever bored entirely under water.

For many years the Pennsylvania Railroad has brought its passengers to Jersey City, and there they have had to stop. The company looked longingly across the Hudson River, but for decades it seemed impossible that this longing could ever be gratified. Engineers wagged their heads doubtfully when the project of a tunnel was broached, and financiers were overcome at the thought of the expense of building a bridge across the river.

Soon after President Cassatt took office, however, at the head of the Pennsylvania system, he determined that the ambition of the railroad should be realized. In his Annual Report for the year 1899 he modestly stated to the stockholders:

"In order that your Company may perform its duty to the public and secure its share of the growing traffic it will be necessary to continue to improve and add to your property."

Then in the report for the year 1901 Mr. Cassatt stated the determination of the road in the following simple language:

"The Board have long felt that your interests, as well as the convenience of the public, require the extension of your line into New York and the establishment of a centrally located passenger station in that city through which the inconvenience and delays of transfer by ferry will be avoided."

The project required capital in unlimited abundance. Above all else, it required extraordinary courage to foresee and to feel sure of the ability of the company to realize from its new improvements sufficient revenue to pay dividends on the largely increased capital. In the reports for 1901 Mr. Cassatt stated his views on this subject as follows:

"The cost of the work will be large, but your Board is satisfied that the expenditure will be fully justified by the results attained."

This work, therefore, will represent, when completed, the culmination of probably the greatest series of railroad improvements ever undertaken. On the Pennsylvania Railroad alone, and excluding its principal lines east and west of Pittsburg, the sum of $192,000,000 has been provided for improvements and extensions during the past six years. Some idea of the vast figures with which the company, under President Cassatt, has come to deal—figures which makes one think of the budget of an empire—may be gathered from the fact that in 1898 the gross income of the Pennsylvania Railroad Company was $71,000,000; the net income was $11,000,000; the dividend paid was five per cent., and the surplus, after paying dividends, was $4,000,000. In 1905 the gross income was $146,000,000; the net income was $30,000,000; the dividend on the largely increased capital stock was six per cent., and the surplus, after paying the dividend, was $11,700,000. In the six years from 1893 to 1898, inclusive, the yearly dividend was five per cent., and the average surplus, after paying the dividend, was $3,700,000 per annum. In the six years from 1900 to 1905, inclusive, the yearly dividend was six per cent. and the average surplus after paying the dividend was $11,400,000 per annum.

To carry through the extremely difficult undertaking involved in the New York City improvements, the Company designated its Third Vice-President, Mr. Samuel Rea, to take direct charge of the work, to superintend the acquisition of real estate, to consult with the New York City and State authorities with reference to obtaining the necessary rights, to appear before the Board of Rapid Transit Commissioners and other public bodies in New York, to explain the project and obtain the necessary franchises and consents, and also to superintend the awarding of the large contracts for doing the work itself. The Company also appointed a commission of the most eminent civil engineers in the world to draw up the plans for the work itself. The commission consists of Colonel Charles W. Raymond, United States Army, Chairman; Mr. Charles M. Jacobs, Mr. Alfred Noble, and Mr. George Gibbs; Mr. Rea and Mr. Cassatt, of course, cooperating with them.

To have direct supervision over the work on the Hudson River tunnels the company secured Mr. Charles M. Jacobs, an Englishman, who has probably had to do with the building of more large tunnels than any other living man. He designed the shields used in the work. The shield is the most important feature of tunneling under water, and it takes an engineer really to appreciate what it means. Four shields have been in use in the Hudson River work, two in each tube, one working from the Jersey side and one from the New York side in each case. The shields are still in perfect condition, and, owing to their peculiarly satisfactory character, this work has been pushed forward with almost unprecedented rapidity.

The Chief Assistant Engineer, Mr. James Forgie, a Scotchman, designed the hydraulic sliding platforms with which the shields are equipped. It is on these platforms that the men stand in making the excavations ahead of the tube itself; the platforms slide out as the work advances, and the excavated material is dumped back through the shield upon tram cars, which carry it back to the shaft.

Mr. Forgie was the principal assistant to the distinguished tunnel engineer, Greathead, in the construction of the Waterloo & City Railway tunnel under the River Thames in 1894.

The contractors, the O'Rourke Engineering Construction Company, began operations in the subaqueous tunnels on April 18, 1904, the first boring beginning on the Manhattan side. On Sept. 1st operations on the New Jersey side were begun, a deep shaft having been sunk on each side prior to the beginning of the actual boring.

Quietly the work went on, and the public heard of little that was happening. Accidents were remarkably few. There was only one death that could be traced to the effects of compressed air; there were inevitably cases of the "bends." Two physicians have been in constant attendance at the works, and everybody who enters one of the tubes has to undergo a rigid examination. Comfortable quarters, well heated and well ventilated, are provided for the workers, and hot coffee is given to them, as a stimulant, when they emerge from compressed air.

The tube itself consists of a series of iron rings, and the installation of every ring means a progress of two and a half feet. Eleven plates and a key piece to go at the top complete the circumferenc, and an entire ring weighs about fifteen tons. The cast iron plates, or sections of the ring, have flanges at right angles to the surface, and it is by these that the successive rings are held together with bolts. Hydraulic rams, placed against the flanges every few inches around the tube, push the shield forward at a maximum pressure of 3,400 tons; if the pressure of the air in the tube be taken into account the pressure upon the shield is increased to 4,400 tons.

The shield itself weighs 194 tons. It has nine doors in it, and through these comes the rock, or sand, or silt, or whatever the material through which the tube must be driven. Thirty men work in a gang, and there are three shifts in the day of twenty-four hours. The record progress so far is five rings, or twelve and a half feet, in eight hours. Men of all nationalities have built the Pennsylvania tubes under the Hudson, negroes having done a

large part of the job. Laziness is something the contractors never had to contend with; they say there must be something about the compressed air which generates energy and enthusiasm, for the "muckers" vie with one another to make the record number of rings.

Perhaps there has never been an engineering project in which theory and practice were so nearly in agreement. The engineers calculated the difficulties closely, and a really remarkable system of reports has been in effect from the first day. Every morning Mr. Jacobs has known the progress made the day before, to the very inch, and the amount of rock and soil excavated, to the cubic foot. The Pennsylvania Railroad officers and the contractors hold this perfect system and the thoroughness of each day's work chiefly responsible for the promptness of the meeting of the tubes.

Engineers say, too, that no project was ever carried out where the emphasis was so entirely upon the results, rather than upon the money it costs to attain them. Records have been kept with unprecedented accuracy and fullness, and they have been corrected, revised and re-revised with bewildering frequency.

Modern Railway Coal Chutes

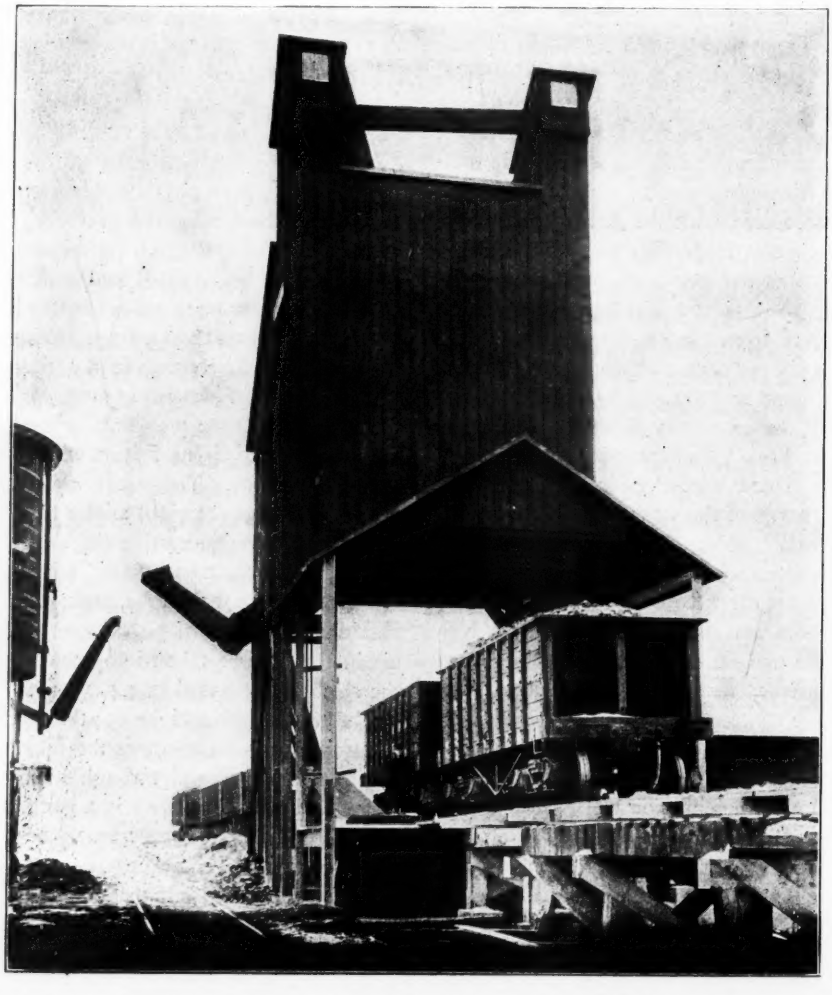
IV.

COALING STATION OF THE WISCONSIN-MICHIGAN RAILROAD AT NATHAN, MICH.

THE underlying principle of what we term modern railway coal chutes is the greatest ease or speed of operation at the least cost. A good many coaling stations are still in operation today under the old style of unloading coal by hand which may cost anywhere from nine to twenty cents per ton to operate. With our long approach trestle type of station and where bottom dump or hopper bottom coal cars are used, the operation is rated from three to six cents per ton. The belt conveyor working with the large hopper into which cars are unloaded is said to be operated at a cost of three or four cents per ton.

The Wisconsin-Michigan railroad in its coaling station at Nathan, Mich., may be said to have the "drop" on most roads of similar size. One man operates the entire station and naturally the cost of operation falls very low. Coal is handled at the rate of two cents per ton, as against the five to twenty cents generally paid.

The unloading process is slightly different from the ordinary receiving hopper. Coal cars to be unloaded are run up over a track one rail of which is supported at intervals by concrete piers. The scheme is somewhat



WISCONSIN-MICHIGAN RY., COALING STATION—VIEW SHOWING DUMPING AND COALING TRACKS AND CONCRETE PIER

similar to that now in common use for engine cinder pits.

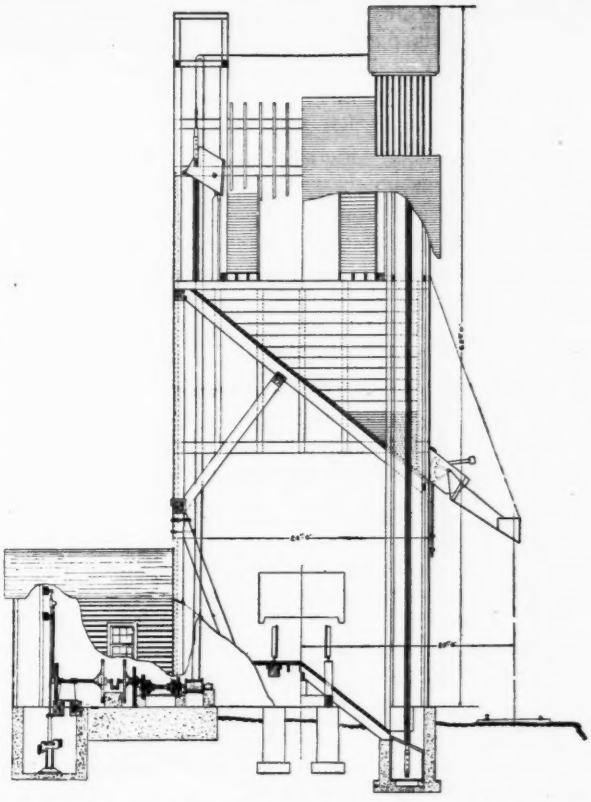
By referring to the sectional view shown this arrangement is readily noted. One of the buckets will be found in position to receive coal at the foot of the incline. Another bucket will be noted as just emptying into the storage bin.

These buckets have an opening 4x3 ft., with a 4-ft. front and a 2-ft. 8in. back. They are hoisted at the end of a 5/8-in. Hercules cable and are so balanced that their weights produce an equilibrium, permitting of easy hoisting and dumping. Angle irons 2x2½x¼ in. and 5 and 14 in. sheaves keep the buckets to their proper vertical course. The bucket operating on the right hand side of the illustration shown here empties at the top of its course into two 3-ft. chutes, each of which dumps into the main coal pocket.

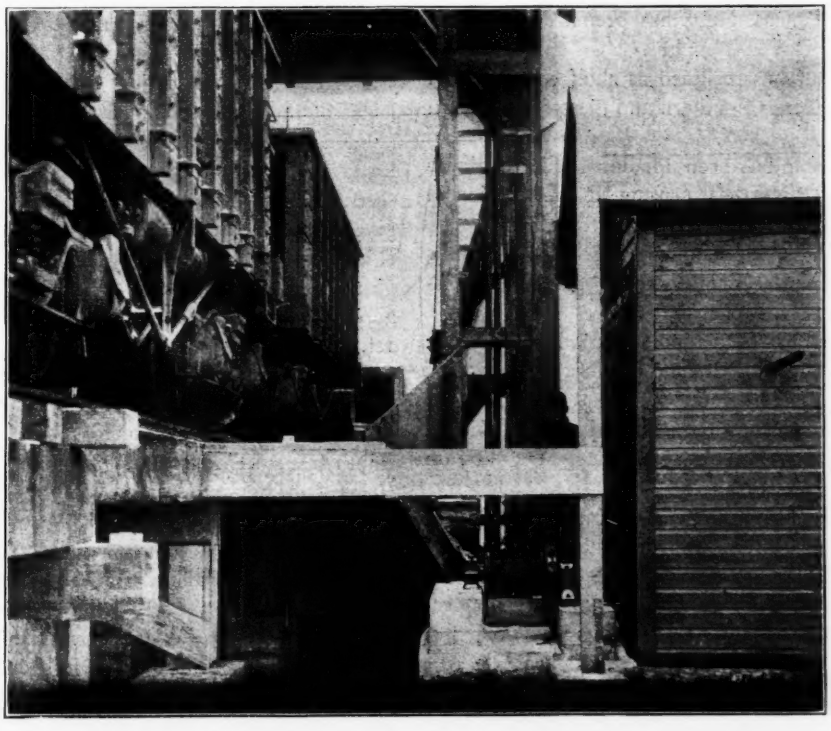
The main coal pocket in this particular Nathan, Mich., station has a capacity of fifty tons, but in larger stations to be built in the future, it is proposed to provide bins with capacities of 100, 150 and 200 tons. The bins or pockets themselves are supported by timber construction, the floors being of 2x12 in. planking. To resist sudden shocks from heavy discharges the pockets are lined throughout with No. 10 steel as a reinforcement.

Beams are 4x12 in. and 6x12 in., with 10x12 in. and 12x12 in. supports. The roof construction has rafters 2x12 in., with 2x8 in. joists and 1x12 in. roof boards.

As to the hoisting apparatus, power is supplied by a 10-H. P. Otto gasoline engine located as shown in the illustration. A Lidgerwood hoist is handled with brake and brake levers, enabling the operator to govern the hoisting without actual attention to the engine. The drum used has an 18-in. width and a 12-in. diameter.



WISCONSIN-MICHIGAN RY., COALING STATION—PLAN SHOWING HOISTING AND DUMPING ARRANGEMENT, STORAGE BINS, BUCKETS, CHUTES, ETC.



WISCONSIN-MICHIGAN RY., COALING STATION—VIEW OF DUMPING TRACK AND HOIST

In addition to the engine and hoist, a 6x18-in. Curtis double acting pump and an overhead device with a 10-ft. pitman and a B jack. The pump is set on a concrete foundation and in a sort of concrete pit.

The dumping track has about a 6-ft. rise over the engine coaling tracks. Piers which have been mentioned before as holding up one rail of the tracks, are all 24 in. square, 6 ft. deep.

There is some difference in the exact rate at which coal is handled by this station, due entirely to the character of the coal. If the small nut coal is handled the maximum rate can be obtained, but where the coal has to be broken up, requiring more, the rate naturally shifts to the minimum. Breaker bars are arranged to separate coal sufficiently, in the center, near the dumping incline.

The whole plant undoubtedly gives the efficiency of service at the least cost of probably any similar requirement in the country. This particular type is the first of its kind ever designed and as explained before mainly economical. The entire plant was installed at the comparatively low cost of $7,000.

To sum up the situation a little more concisely, the plant is operated at a low cost and with facility, since: (1) it may be maintained and operated by one man; (2) its hoisting adjustment permits ready handling free from complication and many repairs. The success of this plant which seems to be of the highest order, will no installments.

Personal

Mr. L. D. Lesseur has been appointed supervisor of roadway of the Western of Alabama.

Mr. J. H. Bowen roadmaster of the Chicago Burlington & Quincy at Seneca, Neb., has been transferred to Sioux City, Iowa.

Mr. N. P. Turner has resigned as chief engineer and roadmaster of the Texas Southern and the office has been abolished.

Mr. T. J. Hardman has been appointed chief engineer of the Shreveport & Northeastern, under construction in Louisiana.

Mr. Arthur Rector, assistant engineer of the Kansas City Mexico & Orient at Fuerte Mexico, has been transferred to Kansas City, Mo.

Mr. J. P. Warren has been appointed roadmaster of the St. Louis Southwestern of Commerce, Texas, in place of Mr. L. Jessup, resigned.

W. D. Crosby, general foreman of bridges and buildings of the Missouri Pacific at St. Louis, Mo., died on August 28th, aged 57 years.

Mr. H. M. Robinson has been appointed division engineer of the western division of the Raleigh & Pamlico Sound, with headquarters at Raleigh, N. C.

Mr. H. L. Montandon, chief engineer of the Orange & Northwestern, with headquarters at Orange, Texas, has resigned to engage in other business

Mr. Walter Washabaugh, assistant engineer in the maintenance of way department of the Southern Railway Washington, D. C., has resigned that position to become general superintendent for Lane Brothers Co. of Esmont, Va., and will have charge of the work for that company in building the Gate City Terminal at Atlanta, Ga.

Mr. B. J. Dalton, who resigned recently as chief engineer of the Denver Kansas & Gulf, has accepted the position of associate professor of engineering at the University of Kansas at Lawrence, Kan.

Mr. C. J. Carrell has been appointed assistant chief engineer of the Mexican International, with office at Cieudad Porfirio Diaz, Mexico, vice Mr. Rankin Johnson, resigned to accept service elsewhere, effective on September 1st.

Mr. H. C. Philips, heretofore chief engineer of the San Francisco & Northwestern, has been appointed chief engineer of the Atchison Topeka & Santa Fe Coast Lines, with headquarters at Los Angeles, Cal., succeeding R. B. Burns, deceased.

Mr. Robert Ferriday, engineer of maintenance of way of the Pennsylvania Lines at Richmond, Indiana, has been appointed engineer of maintenance of way of the Cario division of the Cleveland, Cincinnati, Chicago & St. Louis at Mount Carmel, Illinois.

Mr. W. C. Barrett, assistant division engineer of the Cleveland division of the Baltimore & Ohio, has been appointed division engineer of the Wheeling division at Wheeling, W. Va., to succeed Mr. A. S. Woodle, Jr., who resigned recently to accept a position with the Baldwin Locomotive Works at Philadelphia, Pa.

Mr. Guy Scott, engineer of maintenance of way of the Marietta division of the Pennsylvania Lines, has been appointed engineer of maintenance of way of the Richmond division, with headquarters at Richmond, Indiana, to succeed Mr. Robert Ferriday, who has resigned to accept a position with the Cleveland, Cincinnati, Chicago & St. Louis.

Mr. C. A. Morse, acting chief engineer of the Coast Lines of the Atchison Topeka & Santa Fe, has been appointed chief engineer of the Atchison, Topeka & Santa Fe proper, with headquarters at Topeka, Kansas, to succeed Mr. W. B. Storey, Jr., who has been made chief engineer of the system. Mr. Morse formerly was assistant chief engineer at Topeka, and has been acting chief engineer of the Coast lines since September 1st, 1905. His appointment as chief engineer takes effect on September 1st.

Mr. S. W. Hodgin, assistant engineer of the Chicago Terminal division of the Pennsylvania Lines, has been appointed assistant engineer of the Pittsburg division, Southwest system at Pittsburg, Pa., to succeed Mr. F. N. Crowell, transferred. Mr. W. A. Hawley, assistant engineer of the Richmond division, Southwest system, has been transferred to Chicago to succeed Mr. Hodgin as assistant engineer of the Chicago Terminal division. Mr. J. K. Sherman, assistant on the engineering corps of the Cincinnati division, has been appointed assistant engineer of the Richmond division at Richmond, Ind., in place of Mr. Hawley. Mr. H. W. Brown has been appointed assistant engineer of the Cincinnati & Muskingum Valley division.

Proportioning Concrete

By Sanford E. Thompson, Member of the Boston Society of Civil Engineers.*

As the uses of concrete increase, the necessity grows for a greater economy in construction. To reduce the cost of materials one naturally considers the use of leaner proportions. To decrease the proportion of cement without corresponding loss in strength the aggregate must be specially graded or such materials selected as will increase the density** of the set concrete.

Just how far it is economical to go in increasing the density depends upon the conditions. If, as might be possible on a small job, the cost of materials is reduced 10 cents per cu. yd. by substituting a leaner but denser mixture, and, at the same time, if the cost of labor of preparation is increased by 15 cents per cu. yd., it is obviously poor economy. It may, in fact, sometimes cost more in time and trouble and materials to make a lean concrete of high strength than to attain the desired result by using more cenemt and the materials nearest at hand.

On the other hand, if a large mass of concrete is being laid per day, it may be good economy to spend money for special tests and provide extra machinery for preparation, and even to pay a higher price for the sand or stone in order to secure that which is best suited for the work. The question then is one which must be settled by estimates of cost, and the size of the job is the chief determining factor.

However, special grading of materials is a matter which interests us much less freqently than the practical selection of proportions for structures where the choice of aggregates is limited and the character of the concrete such that the problem is simply one of selecting the best relative proportions of the available coarse and fine aggregate, or, perhaps, comparing two materials which may be obtained at trifling difference in cost. Therefore, before considering the effect of different characters of aggregate, we should first study the experimental methods for proportioning two materials and for simple comparisons of quality.

In experimental determinations for selecting proportions it is a generally accepted fact that for maximum strength we should aim at a mixture having the smallest percentage of voids, but it is by no means settled as to *how* this result shall be obtained even experimentally. For convenience in studying the question we may classify the various plans which are followed.

(1) Arbitrary selection; one arbitrary rule being to use half as much sand as stone, as 1:2:4 or 1:3:6; another, to use a volume of stone equivalent to the cement plus twice the volume of the sand, such as 1:2:5 or 1:3:7.

(2) Determination of voids in the stone and in the sand, and proportioning of materials so that the volume of sand is equivalent to the volume of voids in the stone and the volume of cement slightly in excess of the voids in the sand.

(3) Determination of the voids in the stone, and, after selecting the proportions of cement to sand by test or judgment, proportioning the mortar to the stone so that the volume of mortar will be slightly in excess of the voids in the stone.

(4) Mixing the sand and stone and providing such a proportion of cement that the paste will slightly more than fill the voids in the mixed aggregate.

(5) Making trial mixtures of dry materials in different proportions to determine the mixture giving the smallest percentage of voids, and then adding an arbitrary percentage of cement, or else one based on the voids in the mixed aggregate.

(6) Mixing the aggregate and cement according to a given mechanical analysis curve.

(7) Making volumetric tests or trial mixtures of concrete with a given percentage of cement and different aggregates, and selecting the mixture producing the smallest volume of concrete; then varying the proportions thus found by inspection of the concrete in the field.

Still further variety in methods is produced by different handling of the stone and the sand, some engineers measuring the voids in the stone loose, while others compact the stone to a greater or less degree. Other complications are introduced by the different methods of determining voids, whether by pouring water into the stone or sand, pouring the stone or sand into water or weighing aud calculating the voids from the specific gravity.

After the proportions have been selected, the questions arise as to whether we shall frame the specifications to require loose or packed measurement of the aggregate, loose or packed or arbitrary measurement of the cement, or weight measurement of all the materials; or shall the specifications state that the concrete shall contain a certain quantity of cement in a cu. yd. of concrete? Shall we adopt two aggregates, merely sand and stone, or shall we mix two grades of sand and two grades of stone? These are some of the problems which confront the man who would proportion his concrete for maximum economy.

At the outset we must admit that the nature of the materials used in concrete, the daily and even hourly variation in the quality, sizes and percentage of moisture, prohibit absolute accuracy either in fixing proportions or in practical measurement of materials. Yet different methods ot testing for the purpose of fixing proportions in advance may produce, with the same materials, as great variation as between 1:2:4 and 1:3:7½; surely such possible variations are not to be ignored. Differences in the methods of measuring proportions by the contractor may produce nearly as great variation.

It may be well to review first the causes of the variations in tests for proportions, the sources of errors and the part which good sense and careful judgment must play in the matter. Suppose we consider what may be termed the ordinary method. which is most commonly given in print and employed quite widely in practice,—the method of first determining, separately, the voids in the stone and the voids in the sand, and then proportioning the volume of the sand equivalent to the voids in the stone and the volume of cement slightly in excess of the voids in the sand. The chief variation in the stone, if it does not contain sand or dust, is due to the degree of compacting. Some adopt loose measurement and other packed, while many use slightly shaken measurement. One man may measure broken stone *loose* and find 50 per cent. voids, while another may take the same broken stone and, compacting it, obtain 40 per cent. voids. The proportion of sand in the two cases, if selected strictly by the test, will vary accordingly. The size of the measure also affects the voids.

The voids in stone above ⅜ in. may be correctly determined either by pouring in water, or by weighing and calculating from the specific gravity. In either case, if a porous stone, correction should be made for water absorbed in the pores. Most rock in this vicinity is so dense that this absorption may be neglected. If the stone contains dust, even a small proportion, the air is held in the pores and inaccurate results are reached. Accordingly, for fine material, it is more accurate, in fact necessary, to adopt the weight and specific gravity method. This is also the simplest method with sand, as the specific gravity of sand averages about 2.65. In the vicinity of Boston I have found it slightly higher than this, ranging near 2.7, probably owing to the pieces of trap and other heavy rock contained in

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*Read before the Society at an informal meeting, February 14, 1906.

**The term *density* is used in its now generally accepted meaning, as the ratio of solid particles in a unite volume of concrete. It is thus the complement of the voids. For example, if a piece of concrete has 15 per cent. voids (including the air and the water), 85 per cent. of its volume must be solid material, and its density is 0.85.

it. Either figure is sufficiently accurate to use for void terminations, provided one desires to test the voids. The moisture in the sand must be corrected for by drying a sample and determining the precentage of moisture.

It is thus comparatively easy to find the voids, both water and air voids, in a certain sample of sand, but when we come to figure from these voids the proportion of cement to select, we meet with a greater difficulty than in the relation of the stone to the sand. How shall we select the sample of sand? Shall it be dry or moist, loose or shaken, measured in a small measure or in a large one? Every one of these variations will give a different ratio of cement to sand. Examples of actual tests in my laboratory show that in ordinary bank sand with natural moisture, there may be a difference as great as from 53 per cent. voids when the sand is measured loose to 42 per cent. after shaking.

The effect of moisture on Cowe Bay sand came to my notice in a practical way in connection with tests at Jerome Park Reservoir last winter. In order to make an entry upon one of the tables, although not for direct use in the experiments, as we considered that a knowledge of the voids in sand was of little value, a sample of sand which had been dried in the laboratory was weighed. Its weight was found to be 103 lb. per cu. ft., corresponding to 38 per cent. voids. The same sand was then placed out of doors during a rain, and after lying in the sun for two days following, was retested, and found to weigh 83 lb. per cu. ft., corresponding to 52 per cent. voids. By the theoretical method of proportioning, in one case the proper mortar would be about 1:3 and in the other case about 1:2, and yet the sand was the same and, therefore, the 1:3 mortar would have been only about two-thirds as strong as the 1:2.

I made the statement a few minutes ago that different methods of testing might result, with the same materials, in proportions as widely different as 1:2:4 and 1:3:7½. The case cited shows this difference in the mortar. The difference in the ratio of sand to stone (*i. e.*, 2:4 in one case and 3:7½ in the other) may be reached on the one hand by measuring the stone loose and finding 50 per cent. voids, and on the other by compacting it before measuring the voids and finding 40 per cent. voids.

Perhaps I have dwelt too long upon the inaccuracies of proportioning, but it seems to me that this is a matter of the greatest importance to us in order that we may avoid such inaccuracies, or, at least, exercise very careful judgment in drawing conclusions from them. For example, in the case just mentioned, which is correct, the 1:2:4 or the 1:3:7½? In other words, shall we measure the stone loose or compacted, and shall we measure the sand dry or moist? Or shall we throw aside this method of determining proportions and select some other? As I shall suggest presently, personally I do not place much dependence upon the determination of voids in the different dry materials because of the variations I have mentioned. However, some information may be gained from such tests if the character of the materials is taken into consideration and the methods made to apply to them. For certain materials, for example, the stone may be compacted before measuring the voids and the proportion of sand thus formed, measured loose, will be sufficient to fill the voids when making the concrete. This is the case when the stone is coarse and of fairly uniform size, such as 1½-in. macadam stone, and contains no small stone. The voids are then large, and particles of ordinary sand will fit into them. On the other hand, if the stone is crusher-run, even with the dust screened out, and the sand contains a large proportion of coarse grains, many of these grains will be too large to fit into the smaller voids of the stone, and, therefore, will increase the bulk. Consequently, a larger quantity of the smaller grains must be had, and to do this, the total quantity of sand must be more than enough to fill the voids in the compacted stone. This question of the relative sizes of the grains, which I think was first brought to notice by Mr. William B. Fuller, is frequently neglected in fixing proportions.

This principle is well illustrated in the use of gravel and sand screened from it and remixed. Ordinarily screened gravel, measured loose, has about 40 per cent. voids, so that one would naturally expect a mixture of, say, 1:2:5 to work satisfactorily. If the gravel is compacted so that its voids are 32 per cent., the theoretical mixture would be 1:2:6. However, in practice, the grains of the gravel and sand overlap each other, that is, the smallest grains of gravel are smaller than the coarsest grains of sand, and the voids in the gravel are consequently too small for the large sand grains to enter, so that it is sometimes necessary to use half as much sand as gravel in order to prevent large voids in the concrete.

Experiments by Mr. Rafter, which are of very great value and have been widely quoted, show a surprisingly small proportion of sand. He used 35 per cent. mortar and 40 per cent. mortar both in test and in practice; *i. e.*, the volume of mortar was 33 per cent. and 40 per cent. of the volume of stone slightly shaken. Now, even the larger per cent., 40 per cent. mortar, corresponds to proportions with as little sand as 1:2:6, which probably none of us could use with our New England sand and make good concrete. Our materials would require a 1:2:5 or 1:2½:5 mix. However, if we examine the analysis of Mr. Rafter's sand, we find that 92 per cent. of it passed a No. 30 sieve (30 meshes per linear inch). The grains were thus small enough to enter the voids of the stone without appreciably increasing the bulk; in fact, in many of Mr. Rafter's tests, the volume of the concrete was considerably less than the broken stone slightly shaken. His sand, although apparently so fine, was not of bad quality for concrete work, because there was very little dust in it, and therefore the cement entered the sand voids.

We are coming now to one of the principal points which I wish to make in considering this subject of proportioning. The cases cited show that the experimental void determinations cannot be expected to give practical results, but various allowances must be made. Now, why not, instead of making tests one way or another, guessing at the best way to handle the materials and then altering the proportions by judgment, why not, in the first place, or, at least, after rough determinations to serve as a basis, make up trial mixtures of the materials with the stone and sand and cement and water, and determine, from the appearance of this mixture and the quantity of concrete made from it, and, to go a step further, from the density, or, in other words, the percentage of air and water voids which it contains, whether the proportions are correct? If only two materials are available, the proportions of sand to stone may be determined, after selecting the percentage of cement by mixing the materials in several proportions and selecting the one giving the smallest volume with a given weight of aggregate (corrected, if necessary, for difference in specific gravities); also, judging by the appearance of the mixture, taking care on the one hand that there is sufficient mortar to fill the voids in the stone,—that is, that there is slight excess on top when lightly rammed,—and, on the other hand, that this excess is not too great. The appearance of the concrete also should not be coarse, but there should be enough cement and fine particles of sand or dust to fill the pores and make a fairly smooth mortar.

In the field, this method of inspection is also applicable. In laying the reservoir bottom at Jerome Park, New York City, for example, there was more or less variation in the broken stone and screenings from day to day, and the inspectors were given authority to slightly vary the relative proportions of these two materials, always keeping the proportion of cement to total aggregate at 1:7, so as to give a mix which worked just right in place.

I will not go further into the methods of making these tests, because I do not wish to take too much of your time, but shall be very glad to answer questions in regard to them. Materials cannot be satisfactorily mixed dry by trial with ordinary apparatus and thus proportioned, because there is so great sepa-

ration of the coarse and fine particles. Then, too, the addition of the water changes the relations, since a fine sand requires more water to produce the same consistency than a coarse sand, and consequently makes a larger bulk of mortar. Therefore, for the trial mixtures all of the ingredients must be used, including the cement and the water, as well as the aggregates.

The methods are very useful not only for determining the proportions of two materials but for comparing the value of different aggregates, and also selecting proportions where the aggregate is separated into three or more parts. I have just completed a series of tests for a client in which we found that by changing and grading the sizes of the particles, we could obtain a strength two and a half times as great with the same proportions of cement, while, on the other hand, we could maintain equal strength with 40 per cent. less cement. In connection with such combinations, the use of mechanical analysis diagrams and curves very greatly facilitates matters, and in many cases the correct proportions can be directly predicated in advance if the mechanical analysis curves, for the different materials are plotted from the sieve tests and combined. Mechanical analysis methods are eminently scientific and should be destined to greatly increased use both alone and as an auxiliary to other methods of testing.

From these somewhat general observations and from the results of tests which cannot be presented this evening, we may offer the following suggestions as guides to proportioning:

(1) The size of the largest stone in the aggregate should be as great as is consistent with proper placing of the concrete.

(2) If size of stone is small, a richer mixture must be used; thus 1:3:6 is a fairly rich mix with 2-in. stone, but a lean mix with ½-in. stone.

(3) If sand is fine, a smaller quantity may be used in proportion to the stone.

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(4) For concrete a sand with to large a percentage of very coarse grains may be detrimental because they will not fit into the voids of the coarse aggregate.

(5) If the broken stone or gravel contains fine stuff, a smaller proportion of sand must be used.

(6) Better proportions are obtained in practice by screening the sand or dust from the coarse material and remixing in required proportions than by using the run of the bank or the run of the crusher.

(7) If the mortar in concrete is rich, say, up to 1:2½, sand should be coarse, with comparatively few fine grains. A lean mortar, on the other hand, is improved not only in strength but in smoothness of working, by using a sand containing dirt or dust.

(8) If fine sand must be used, the proportion must be richer than for coarse sand, because a fine sand makes a mortar of lower density.

A very important point still in question is with reference to the use of fine sand for water-tight work. A few permeability tests which I have made recently indicate that a slight excess of fine grains in the sand is often beneficial for concrete designed for water-tight work. For example, I greatly increased the water-tightness of a 1:3:6 concrete made with ordinary coarse bank sand of a quality to produce a strong mortar, by substituting for one-sixth part of the sand an equal weight of very fine bank sand. This fine sand decreased both density and strength and yet increased the water-tightness. A further increase in fine sand did not appreciably affect the water-tightness at an early age, but on longer time tests the specimen with the small addition of fine sand was much superior to those with a larger quantity of fine grains. In a 1:2:4 concrete made with coarse bank sand, an addition of fine sand did not improve it, evidently because there was a sufficient excess of cement to render more fine sand unnecessary.

*Protecting Galvanized Iron**

On the West Jersey Division of the Pennsylvania R. R. we had a great deal of galvanized iron which in the past has given us considerable trouble. Much of it is used on small station buildings and sheds but the proper way of protecting it in these localities has not been as difficult to determine as the manner of presering our large and expensive building, covering the Market Street Ferry Slips on the Camden, N. J., side. The conditions to be met with in that locality are particularly severe. There is much dampness all the time and there are frequent fogs which absorb the gases escaping from the adjoining train shed and from the sewers emptying into the Delaware. These gas-laden fogs settle down on the iron as condensation, full of carbonic and sulphuric acids. The average paint won't stand such an exposure very long and we consequently have had a great deal of trouble from rusting until we came across Bessemer paint which seems to fill the bill to perfection in connection with the Galvanic Primer, about which I shall give further details later on.

In the country we do not have gases and frequent fogs to contend with and our Standard Paint would have answered the purpose nicely if only we had gotten it to adhere properly everywhere. Of course, we did clean off the galvanized iron before painting but did not wait for it to become rusty. I am aware of the maxim laid down by many leading painters that galvanized iron should never be painted until it has become weather worn, but for various reasons we did not follow it. In fact, I could never get myself to believe in this theory because it looked so absurd to go to a lot of expense in having the iron galvanized and to hope that the weather would destroy what you have paid for. To make up for this heresy, I have tried a whole lot of other ways and washes recommended to me by various experts and by books on the subject. I have used vinegar, sulphuric acid, ammonia, muriatic acid and even a mixture of acids and chemical salts recommended by one of the paint journals. The results which I got with these nostrums were generally fair but not uniform. In other words, wherever I had used them there was not as much peeling as before but no matter what I used and how carefully I used it I never was able to stop the peeling altogether.

And then finally I made up my mind to do what I should have started with. I concluded that after all theories had failed me I might just as well study up the facts and find out why paint should have such a tendency to pull away from Galvanized Iron so that after knowing the reason for it, I might be better able to intelligently devise a remedy.

The first thing I did was to find out all I could about Galvanized Iron and it may interest you to hear that after reading a great deal about the discovery and development of the art of dissolving and depositing metals by the Galvanic Process I ultimately found that this process had nothing whatever to do with the manufacture of Galvanized Iron. Our manufacturers all make Galvanized Iron in about the same manner as they make Roofing Tin. The only difference is that instead of taking the iron and steel plate and dipping it into molten tin they immerse it into molten zinc. Just then I came across something that at once arrested my attention. I found that in order to protect the molten zinc from contact with the air, the manufacturers kept it covered with strong ammonia water. Naturally, when you pull the zinc covered plate out of this bath some of the ammonia will stick to the coating and you all know what strong ammonia will do to paint. Right on top of this I found another bad thing for paint and that was a non-drying oil. It seems

*From a paper prepared by Mr. Edward Heimack, Master Painter, Philadelphia & Camden Ferry Co., Camden, N. J., for the Master Car & Locomotive Painters' Convention, and published in the Railway Master Mechanic for October, 1906.

that after the zinc plate has left the bath, it is immediately hung into a tank with hot non-drying oil with the object of givng any excess of zinc a chance to drain off before it has had time to congeal. The plate, which by this time has had little particles of strong ammonia and non-drying oil sprinkled all over it, is now ready for the polishing rollers in which these particles or drops are rolled out all over the zinc coating and are squeezed and polished into it. Now, I knew and no longer wondered why we had so much trouble in getting paint to stick to Galvanized Iron. The reason is simply that wheverer the ammonia predominates, it will be taken up by the oil in the paint which it destroys, causing the paint to crumble and that wherever the non-drying oil is spread in a film over the plate, the paint cannot get a hold therefore in time must form a blister. Right here may be a good occasion to explain a fact known to most observers that Galvanized Iron is more rustproof than tin in the beginning and nearly always less durable than tin after the rust has got a good start. "There is a reason," as the patent medicine man says, who won't let us enjoy our coffee, and I find this reason to be due to the way in which electricity acts on various metals. Some metals are much more easily attacked by it than others and on this knowledge the Galvanic Process is really founded. If you take two metal plates and connect them with a supply of electricity so that the current will make a circuit you will find that the plate which possesses the greater amount of resistance will reject the current and will therefore be electro-negative. All of the current will necessarily pass through the other plate which is not strong enough to resist it and which will therefore be electro-positive. One and the same metal may be electro-positive or electro-negative according to its position near to another metal, having a greater or less attraction for electricity; thus if you put a steel plate and zinc plate into a bucket of water and pass an electric current through them, the steel being the stronger will be electro-negative and the zinc having more affinity for electricity, will be electro-positive, which means that the steel will not admit the current and will therefore remain as it is, while the zinc will become the subject of electrolysis and will rapidly change into oxide of zinc, a whitish powder. This knowledge has been used in a very ingenious manner for the protection of boilers using salt water which is apt to rust the boiler plates very badly. To prevent this a few plates of zinc are fastened against the boiler plates and now all one has to do is to replace these zinc plates whenever they have been entirely corroded. I understand that this is done and has been done right along by the English Navy and maybe also by ours. Now, change your experiment by substituting a plate of tin for the one of zinc, but leaving the steel plate in place and as soon as you turn on the current, you will find that the steel has become electro-positive, which means that instead of leaving it indifferent as before the electricity will now corrode it, changing it into oxide of iron, which is nothing less than rust. Now, as we have already seen, the Galvanized Iron plates as well as tin plates of commerce are nothing else but iron, or rather steel, covered with a veneer of zinc or tin. As long as this veneer remains intact, electricity will not hurt either kind, but let the surface be imperfect or let it become broken and the galvanic action demonstrated by our experiments will take place; an electric current will start to oxidize the zinc on the galvanized plates, but will leave the steel intact, because, as you may remember, this possesses a stronger resistance than zinc and therefore is electro-magnetic. Theoretically, this is always the case but in practice it may happen that an opposite action develops which all of you have no doubt observed where iron nails have been driven into galvanized iron. You also may have observed that sometimes this starts rusting and sometimes it does not, particularly where the zinc is well protected with paint. This is due to the tendency of the zinc, already mentioned in the former part of my paper, to become coated with a thin film of oxide of zinc, wherever it is exposed to the air. This film which might properly be called zinc rust, is very tenacious and insoluble in water and it will protect the zinc under it and it is often depended upon to protect the entire structure coated with galvanized iron and not painted. I would, however, advise not to depend on this film of oxide of zinc, because it is quite brittle and easily injured and as soon as it is broken the zinc, on account of the change that has taken place in it, will become electro-negative instead of electro-positive as it was before and the consequence will be that the iron will have to assume the electro-positive role just as it does in the case of the tin plate. In the case of the tin plate the break will have the opposite result allowing the electricity to decompose the iron which is bounded on all sides by the electro-negative tin. The result of this action will be a thin veneer of tin, that looks entirely solid but that will collapse all of a sudden in those parts where the iron has become honeycombed with rust. Of course, this electrolytic action is not as pronounced in practice as it is in the laboratory, because the supply of electricity in the atmosphere is not very great or continuous, except where a feed wire or even a telephone wire furnishes the broken sheet with an independent supply of electricity.

I hope that I have not spent too much time in an endeavor to explain the action of electricity on galvanized iron. The deteriorating effects from galvanic action are no doubt determined largely by the surroundings and I think it is more than likely that they would never be suspected on a freight shed in the country, while in all likelihood they play quite an important part in the case of our ferry shed with a lot of wires, carrying heavy currents, passing through and over it. The thing which should not be lost sight of is that electricity is only one of the agents that cause galvanized iron to become decomposed and that as we have seen, it does not even do so directly, but at the same time does it effectually, by eating up the zinc and laying bare the iron, thus exposing it to the various rust producing agencies.

You may have noticed that I have been using the words iron and steel rather indiscriminately. The fact is that I should always have spoken of steel and not of iron. The term of "galvanized iron" which we all use is quite wrong, if my information is correct. I hold it on very good authority that nowadays very little iron is produced and that if you place an order with the Steel Trust for iron you will invariably get steel. I have been told by a large chemical manufacturing concern which ordered iron plates for some of their buildings, that they insisted that the material must be iron and not steel. When the order was filled they refused to accept the plates, claiming that they were steel. This led to a long dispute because it is rather difficult to draw a line between iron and steel, but as in this case the chemist was a very able man and one who stuck to his guns, the manufacturers had finally to admit that their plates might be called steel but that it would be impossible for their clients to get iron ones anywhere in the United States, unless they paid a fancy price for having them made to order. I am told that the "iron" as we get it now, which really is steel, is better for all practical purposes, being more flexible and tougher than the real iron, but that it must be admitted, that it will rust more easily.

Now, I have given you an outline of pretty nearly all that has looked to me as if it might be worth mentioning, with the exception perhaps of the very well known fact that unprotected galvanized iron will never prove durable in the neighborhood of Train Sheds, Rolling Mills, Gas Works, Glass Works, Iron Foundries and in places where a considerable amount of carbonic and sulphurous gases is discharged into the surrounding air. Zinc is very easily decomposed by all acids, as well as by the salt air of the sea coast and in all such localities it would be just as well to use plain sheet iron and to paint it thoroughly.

However, I am getting away from the subject of my paper, which was to tell how to protect galvanized iron adequately. It won't take me more than a minute to tell you what it has taken me a long time to discover. I have already mentioned that I have found Bessemer paint to be thoroughly proof against the action of the weather and chemical influences and that for this reason I was using it on the Camden Terminal.

Improvement of the Surface Tracks of the Brooklyn Bridge.

The engineers of the New York bridge department in charge of the Brooklyn bridge have for some time agreed that the surface car tracks across the structure are worn out and that the roadbed and tracks need replacing, a necessity which arises about once a year. The interruption to traffic, which usually causes much grumbling from that portion of the public using the bridge during renewal alterations, the necessity of working in sections, and the short life of the light roadbed and strap rails when installed, make the work difficult.

With the purpose of avoiding, is possible, these difficulties the bridge department appealed recently to the Brooklyn Rapid Transit Company, and Chief Engineer W. S. Menden of that company expressed the belief that a stronger rail than the old strap rail could be devised for the trying needs of the bridge without adding materially to its burden. He suggested the use of a rail of managanese steel which he thought would last eight or ten years instead of as many months. The bridge engineers has endorsed Mr. Menden's plan and have decided to install the rails at once.

The work will be prosecuted with the greatest possible dispatch and to that end the bridge commissioner has ordered that the night service of surface cars be more extensively abandoned during its progress than ever before. Steel, crossties, and paving material were delivered beforehand at the bridge and the work was begun on October 1. Beginning on that day surface cars were not run across the bridge structure from 8:30 p. m. to 5 a. m., except Sundays, when the all night service will be given as usual. To help replace the withdrawn surface cars extra shuttle trains will be run upon the elevated tracks and transfers freely exchanged between these and the surface cars which will be run to the plaza.

The construction will be further improved by welding the rails. To allow for contraction and expansion under varying temperatures there will be five expansion joints in the roadbed.

The long stretches of track along the anchorages and approaches of the bridge are to be relaid with the heaviest girder rails rolled. The factor of weight does not enter on the solid parts of the bridge and a track with concrete foundation is to be laid that would be capable of bearing a heavy train load.

In order greatly to facilitate and hasten this work of track renewal the storage yard of supplies was placed in the plaza. More supplies have been placed in every available corner all the way across the structure and with the materials so close at hand the track gangs should progress rapidly. The opportunity will be improved by the electricians who will string new overhead wiring while the tracks are being renewed and thus give the whole of this congested line a new outfit for the great work it is compelled to bear.

Superintendents of Bridges and Buildings Convention.

The sixteenth annual convention of the Association of Railway Superintendents of Bridges and Buildings will be held at the American House, Boston, Mass., on Oct. 16, 17 and 18. The subjects for report and discussion are as follows:

"Concrete Bridges, Arches and Subways," G. E. Hanks, Pere Marquette, Saginaw, Mich., chairman.

"Experience and Use of Concrete and Timber Piles," W. H. Finley, C. E., Chicago, Ill., chairman.

"Concrete Building Construction," C. W. Richey, master carpenter Pennsylvania Lines, Pittsburg, Pa., chairman.

"Method of Watering Stock in Transit." J. N. Penwell, Lake Erie & Western, Tipton, Ind., chairman.

"Recent Practices in Coffer-dam Work," G. Aldrich, New York, New Haven & Hartford, Readville, Mass., chairman.

"Modern Coaling Stations and Cinder Pits," J. S. Browne. New York, New Haven & Hartford, Providence, R. I., chairman.

"Bumping Blocks for Passenger and Freight Use," A. E. Killam, Intercolonial, Railway, Moncton, N. B., chairman.

Committee reports on standing subjects will be submitted as follows:

"Pile and Frame Trestle Bridges," J. P. Canty, Boston & Maine, Fitchburg, Mass., chairman.

"Steel Bridges," A. O. Cunningham, Wabash, St. Louis, Mo., chairman.

"Buildings," W. B. Causey, Chicago & Alton, Bloomington, Ill., chairman.

"Water Supply," B. M. Hudson, St. Louis, Kansas City & Colorado, Union, Mo., chairman.

"Fire Protection," George W. Andrews, Baltimore & Ohio, Baltimore, Md., chairman.

"Fences, Road Crossings and Cattle Guards," A. Findley, Grand Trunk, Montreal, Que., chairman.

"Preservatives for Wood and Metals," F. D. Beal, Southern Pacific, West Oakland, Cal., chairman.

"Records and Accounts," R. C. Sattley, division engineer Chicago & Northwestern, Winona, Minn., chairman.

The following subjects, reported on at the last meeting, will also be taken up for discussion:

"Construction and Maintenance of Docks and Wharves"; "Concrete Building Construction, Including Platforms"; Anchors for Plows and Derricks"; "Methods of Repairing Roofs of Various Kinds"; "Protection of Water Tanks and Water Pipes from Action of Frost"; "Steel Bridges"; "Preservatives for Wood and Metals"; "Records and Accounts."

The convention will be called to order at 10 A. M. Thursday afternoon, Oct. 18, and Friday, Oct. 19, will be devoted to pleasure trips. On Wednesday evening Prof. G. F. Swain, of the Massachusetts Institute of Technology, and a member of the Transit Commission of Boston, will deliver an address at the annual banquet of the association.

The Adreon-Morse Ratchet Wrench

In the accompanying illustration is shown the Adreon-Morse ratchet wrench which is a simple and practical reversible wrench suitable for all purposes in railroad shop, track, bridge and structural work. The advantages claimed for this wrench are its strength, durability and simplicity of construction. The working

THE ADREON—MORSE RATCHET WRENCH.

parts are completely enclosed within the frame, obviating the possibility of dirt or grit being admitted. The turning of the small lever accomplishes reversing of the wrench from left to

right. Sockets for any size wrench may be placed within the frame in a moment, both flush and extension sockets being furnished. The wrench is fully warranted and Adreon & Company, St. Louis, Mo., who offer it for sale, have found that it has been approved by practical railroad men.

Maintenance of Way Painters' Convention

The Association of Maintenance of Way Painters of the United States and Canada will hold its annual meeting in New York City, November 13-14, 1906. Mr. Harry J. Schnell, 39 Summit street, East Orange, N. J.

New Shops and Roundhouses

The following new shops are under construction or contemplated: Maine Central, car repair shops, extension, 39x362 ft. at Waterville, Me., under construction; Chicago, Milwaukee & St. Paul, additions to its shops at West Milwaukee, to cost $300,000; Alabama Great Southern, car shops at Gadsden, Ala., under way; The Cincinnati, Bluffton & Chicago will probably build its shops at Huntington, Ind.; Seaboard Air Line, addition to shops at Savannah, Ga.; Western Railway of Alabama, contract reported awarded to Cook & Laurie Contracting Co. for a number of shop buildings at Montgomery, Ala.; The St. Louis, Rocky Mountain & Pacific will locate its shops at Cimarron, N. M.; The Cleveland, Terminal & Valley (Baltimore & Ohio) will build shops at Cleveland, O.; The Kansas City Southern will make improvements to its shops at Pittsburg, Kan.; The Chicago & Western Indiana will build a machine shop, storehouse and oil house at Chicago; The Atchison, Topeka & Santa Fe has under construction additional shop buildings at Topeka, Kan.; The Tidewater Railway will locate its main shops at Salem, Va., and division shops at Victoria, Lunenburg county, Va., and Roanoke, Va.; The Grand Trunk is building large shops at Battle Creek, Mich.; Wells Bros. & Co., New York, N. Y., have the contract for several shop buildings for the Baltimore & Ohio at Wheeling, W. Va.

Roundhouses, as follows, are reported contemplated, or under construction: Minneapolis & Rainey River, 10-stall engine-house, with 66-ft. turntable, at Deer River, Minn.; Southern Railway, 12-stall engine-house at Asheville, N. C., under construction; Oregon Railroad & Navigation Co., contract reported given to Robert Wakefield, of Portland, Ore., for an engine-house, oil and store houses, and coaling station at La Grande, Ore.; The Cleveland, Terminal & Valley (Baltimore & Ohio) will build a roundhouse and coaling station at Cleveland, O.; St. Louis & San Francisco, contracts let for a large roundhouse at Fort Scott, Kan.; The Great Northern is building a 40-stall roundhouse at Minneapolis, Minn.; The Chicago & Western Indiana will build a 51-stall roundhouse at Chicago.

Miscellany

S. F. Bowser & Co., Fort Wayne, Ind., recently received the contract for an oil house equipment for the storehouse of the Toronto, Hamilton & Buffalo Railway at Toronto, Ont.

The Lyon Metallic Manufacturing Co., formerly at 18 South Ann Street, Chicago, has removed its factory and general offices to Aurora, Ill., where better and increased facilities have been obtained. The company will maintain an office at No. 1211 Marquette Building, Chicago, which will be in charge of Mr. L. Wilkinson.

Mr. Paul Dickinson, Chicago, Ill., head of the railroad supply house bearing his name, died at his home in Winnetka, Ill., August 31, of anæmia. He had been ill for some months, but until recently was still able to give attention to business affairs. Mr. Dickinson was well known in connection with his work on engine house ventilation, and his firm made a specialty of smoke jacks.

The H. A. Rogers Company, 19 John Street, New York City, report that the local railroad demand for track and machine shop supplies is extremely heavy.

Secretary-Treasurer H. S. Balliet of the Railway Signal Association, announces the new date for the Washington convention as Oct. 16-17-18, 1906. The New Willard will be the Association headquarters. This change was made necessary by the fact that two large conventions were scheduled for the old date of Oct. 9-10-11, and in view of the usual large attendance at the Signal conventions it was deemed best to select a time that would give an unobstructed horizon for business

The Philip Carey Mfg. Co., Cincinnati, Ohio, had their annual convention of district managers at the home office during the first week in September. The convention was called for the purpose of going over the conditions of trade in the different parts of the country represented as well as to consider how to improve the business. For this purpose they had day and night sessions, finishing with a banquet at the Queen City Club. All the managers reported good business as could only be expected with the quality of material handled. It is widely known that he Philip Carey Mfg. Co. are manufacturers of magnesia flexible cement roofing as well as asbestos sectional steampipe and boiler coverings. The former is used in all climates for roofing for anything from a private residence to the large factory buildings or railroad terminals while the latter is used by too many to need any comments.

Mr. T. W Snow, who for some years has been manager of the Otto Gas Engine Works, Chicago, has been elected president of that company to succeed the late Mr. John Saltar, Jr. Mr. Snow will continue to have charge of the railway department of the company, with offices at 357 Dearborn St., Chicago, but will divide his time between Chicago and Philadelphia, where the plant of the company is located. Messrs. R. E. Gurley and R. A. Ogle of the St. Louis office have been transferred to Chicago, but the St. Louis office will be maintained. Mr. Snow has been manager of the Western office, and the railway department of the Otto Gas Engine Works since 1899.

"Through Frisco's Furnace" is the title of a handsome brochure just issued by the Joseph Dixon Crucible Co., Jersey City, N. J. It is descriptive pictorially of the terrible calamity that was the undoing of that city on the coast on April 18, showing by large half-tones the awful havoc made by the 'quake and fire. Underlying all is seen the proof of the value of Dixon's Silica-Graphite Paint, which resisted the ravages of the flames. The facts so convincingly presented, of the preservative qualities and endurance of this paint under such extraordinary trials, are well supplemented by the engravings which cannot be excelled. Those interested may obtain copies for the asking, as above.

An unusually instructive, neat and attractive catalogue is being distributed by the Quincy, Manchester, Sargent Company, Old Colony Building, Chicago, which fully illustrates and describes its metal sawing machinery, including both stationary and portable saws as well as a complete line of portable rail saws and power hack saws. In addition to these, particular interest attaches to the descriptive matter concerning cylinder boring bars for both compound and simple locomotives, boring bars for lathes, portable valve seat rotary planing machine, portable crank turning machines, universal planer chuck, radius planer attachment, flue welding and cleaning machines, car wheel grinding machines, etc., and the company's capacity for providing further facilities in meeting the demands of up-to-date railway shops is shown in the illustrations of cranes, trolleys, air hoists and fittings in addition to the riveting machinery for all classes of work. The catalogue also describes many other devices for use in the mechanical and operating departments of railroads such as self-locking steel nuts, engine and car replacers, emergency knuckles, diaphragms, snow flangers and other appliances largely used.

The offices of the Hicks Locomotive & Car Works have been removed from the third to the seventeenth floor of the Fisher Building, Chicago.